# Early hemodynamic resuscitation in septic shock

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COMMENTARY

# Early hemodynamic resuscitation in septic shock: understanding and modifying oxygen delivery

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See related research by Ospina-Tascón *et al.*, http://ccforum.com/content/17/6/R294

**Abstract**

In a previous issue of *Critical Care*, researchers have focused on the venous-to-arterial carbon dioxide difference (Pv-a$CO_2$) as a surrogate marker for systemic perfusion in patients with septic shock. Although the complex mechanisms responsible for an increased Pv-a$CO_2$ in septic shock need to be further unraveled, the potential prognostic value of Pv-a$CO_2$ seems clinically relevant and useful in daily practice in view of its easy availability.

The resuscitation of patients with sepsis remains a challenging task. In the presence of shock, early optimization of global and regional perfusion mandates adequate monitoring. Whatever kind of monitoring is used, it should provide reliable information with potential therapeutic and prognostic relevance. In a previous issue of *Critical Care*, Ospina-Tascón and colleagues [1] describe a potentially useful tool as a target for resuscitating early septic shock. The Surviving Sepsis Campaign guidelines for early hemodynamic optimization recommend normalization of central venous oxygen saturation ($ScvO_2$) [2]. $ScvO_2$ reflects the imbalance between oxygen delivery ($DO_2$) and oxygen demand ($VO_2$). However, in the majority of patients with severe sepsis or septic shock who are acutely admitted to the ICU, $ScvO_2$ values are normal or elevated (>70%) [3]. Hence, an additional circulatory parameter is needed to evaluate resuscitation efforts.

Ospina-Tascón and colleagues [1] have focused on the venous-to-arterial carbon dioxide difference (Pv-a$CO_2$) as a surrogate marker for systemic perfusion in patients with septic shock. This could make sense. Indeed, Pv-a$CO_2$ may be used to mathematically calculate cardiac index [4]. In addition, a cutoff value for Pv-a$CO_2$ of 6 mm Hg may be used to discriminate between high and low lactate clearance and cardiac index in critically ill patients who were seemingly resuscitated [5].

In a prospective observational study, Ospina-Tascón and colleagues [1] classify their patient population into four predefined groups based on the evolution of Pv-a$CO_2$ during the first 6 hours of resuscitation. A Pv-a$CO_2$ of at least 6 mm Hg was considered high (H), and a Pv-a$CO_2$ of less than 6 mm Hg was considered normal or low (L). Their results show that two groups have better outcome: that is, patients with low Pv-a$CO_2$ throughout the observational period (LL) and patients in whom Pv-a$CO_2$ decreased from high to low values (HL) [1]. The patients in the first group were either less severely ill or already adequately volume-resuscitated before ICU admission. Analogously to earlier findings [5], the HL patients may be considered responders to treatment mirrored by the significant lactate clearance from 2.7 to 1.3 mmol/L. In contrast, persistently high Pv-a$CO_2$ values (HH) or increasing Pv-a$CO_2$ values (LH) predicted worse outcome. The patients in the HH group were too severely ill, and during treatment for the patients in the LH group a substantial oxygen debt was probably recognized too late. In addition, an increased mortality risk was observed when patients reached an $ScvO_2$ of at least 70 % with concomitantly high Pv-a$CO_2$ values. This is in line with recent findings that Pv-a$CO_2$ may be used as triage tool when $ScvO_2$ values are more than 70% on ICU admission [5,6]. Hence, Pv-a$CO_2$ may potentially be of prognostic value. In addition, Pv-a$CO_2$ values can be easily obtained with low costs, making this parameter potentially clinically relevant and useful in daily practice.

Nevertheless, one has to bear in mind that the mechanisms responsible for an increased Pv-a$CO_2$ in patients with septic shock are not fully understood yet. On the microcirculatory level, distributive changes may be independent of cardiac output (CO) [7]. This means that on a regional level, in accordance with the possibility of

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persistent hypoxia despite normal $ScvO_2$ levels, the accumulation of carbon dioxide ($CO_2$) occurs in microcirculatory weak units, despite adequate CO. However, Pv-a$CO_2$ reflects the ability to wash out the accumulated $CO_2$ better than the presence of anaerobic metabolism [7,8]. Also, an increased Pv-a$CO_2$-to-$VO_2$ ratio could reflect global anaerobic metabolism [9], and the ratio of Pv-a$CO_2$ divided by arteriovenous oxygen content difference predicts an increase of oxygen utilization after a fluid-induced increase in $DO_2$ [10]. This means that Pv-a$CO_2$ values may also be of therapeutic relevance. A decrease of heterogeneity of the microcirculation may potentially result in an increased $CO_2$ washout and a decreased Pv-a$CO_2$-to-$VO_2$ ratio. Also, the balance between $DO_2$ and $VO_2$ may be restored. It is tempting to hypothesize that the necessary improved recruitment of microcirculation in the early resuscitation phase may be achieved by the use of vasodilatators in addition to volume loading [11,12]. Indeed, the results of Ospina-Tascón and colleagues may provide an argument to implement vasodilators within 6 hours, which probably could be stopped after recruitment has occurred. Such a strategy may be particularly beneficial to septic shock patients resembling the patients described in the LH group.

In conclusion, Pv-a$CO_2$ provides us with additional information to hemodynamic and oxygen-derived parameters currently used in the resuscitation of patients with sepsis. Pv-a$CO_2$ values seem clinically relevant and are potentially of prognostic value.

#### Abbreviations

CO: Cardiac output; $CO_2$: Carbon dioxide; $DO_2$: Oxygen delivery; HH group: Patients with persistently high venous-to-arterial carbon dioxide difference values; HL group: Patients with decreasing venous-to-arterial carbon dioxide difference values; LH group: Patients with increasing venous-to-arterial carbon dioxide difference values; LL group: Patients with persistently low venous-to-arterial carbon dioxide difference values; Pv-a$CO_2$: Venous-to-arterial carbon dioxide difference; $ScvO_2$: Central venous oxygen saturation; $VO_2$: Oxygen demand.

#### Competing interests

The authors declare that they have no competing interests.

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